

Incorporation of Dialogic Learning in STEM Classrooms

67th Annual Meeting of the APS Division of Plasma Physics

Marisa Petrusky, Dusty Martinez, Kachine S. Kulick

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University of Colorado Boulder

What is Dialogic Learning?

- Dialogic learning uses guided **communication activities** to **enhance comprehension** of a topic and **foster engagement** across different perspectives
- **Knowledge is co-constructed** by educators and students
 - **Empowers students** as they learn from each other AND educator
 - Educator takes **mentor-like role**, guiding students to knowledge rather than simply telling them



Dialogue v.s. Debate v.s. Discussion

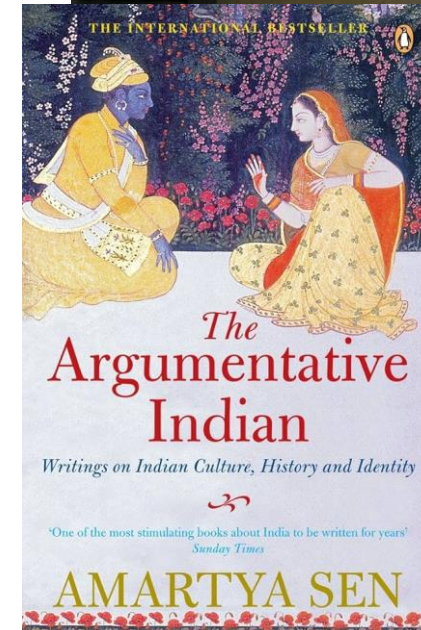
	DEBATE	DISCUSSION	DIALOGUE
Methodology	Defend your argument	Present ideas/information	Share ideas/experiences
Answers?	Prove answers	Find answers	Develop understanding
Contradictions?	Point out weaknesses	Discuss pros and cons	Allow for differences
End goal	Win with best argument	Find consensus for solution	Broaden perspectives

Dialogue is distinct from debate and discussion
in its **open-endedness**

Adapted from “Why a Dialogic Classroom?”, Essential Partners, 2023.

Why Use Dialogic Practices in STEM Classrooms?

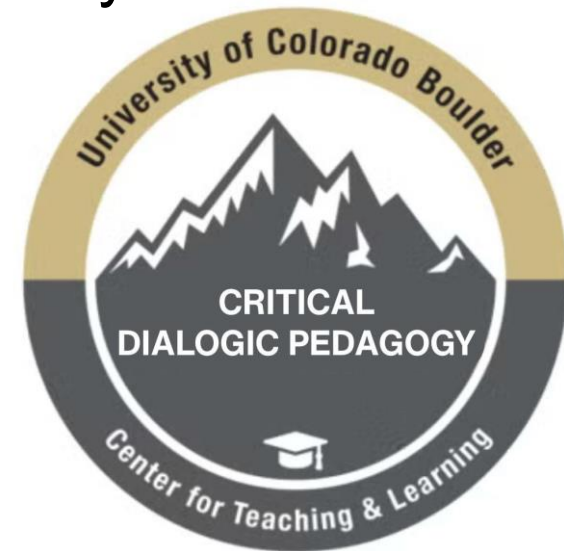
- Key outcomes for students:
 - **Stay engaged** during lecture
 - Practice **communication, critical-thinking, reasoning** skills
 - **Improve self-efficacy** through communal learning
 - **Build community** among peers and with educator
- Key outcomes for educators:
 - Practice **communication** and **facilitation** skills
 - **Mastery of course content**
 - **Gauge student understanding**
 - Cultivating an **inclusive environment**
- **Challenges** for STEM:
 - **High density of course content** per lecture
 - Few precedents for incorporating dialogue in collegiate STEM classes
 - Most research is done on dialogic pedagogy in K-12 education



Dialogic learning has been used throughout history! (Book cover: *The Argumentative Indian* by Nobel Prize winner Amartya Sen)

Objectives and Agenda

- **GOAL: Introduce** audience to the **process of developing and incorporating a dialogic activity** into a STEM lecture
 - NOT a skill that can be learned in one session
 - I began learning this skill via a **semester-long micro-credential course**
 - Requires **commitment** to the work, **practice**, and willingness to **make mistakes!**
- QR Code linked to copy of slides included at end of the presentation
- Backup slides: Dialogic facilitation practice, activities, examples to try!

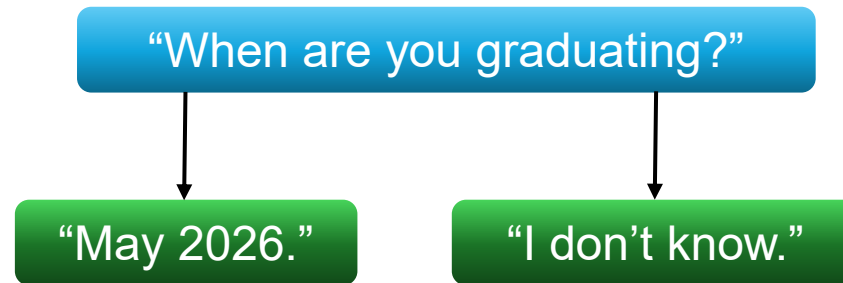


Step 1: Develop a Prompt Conducive to Dialogic Learning

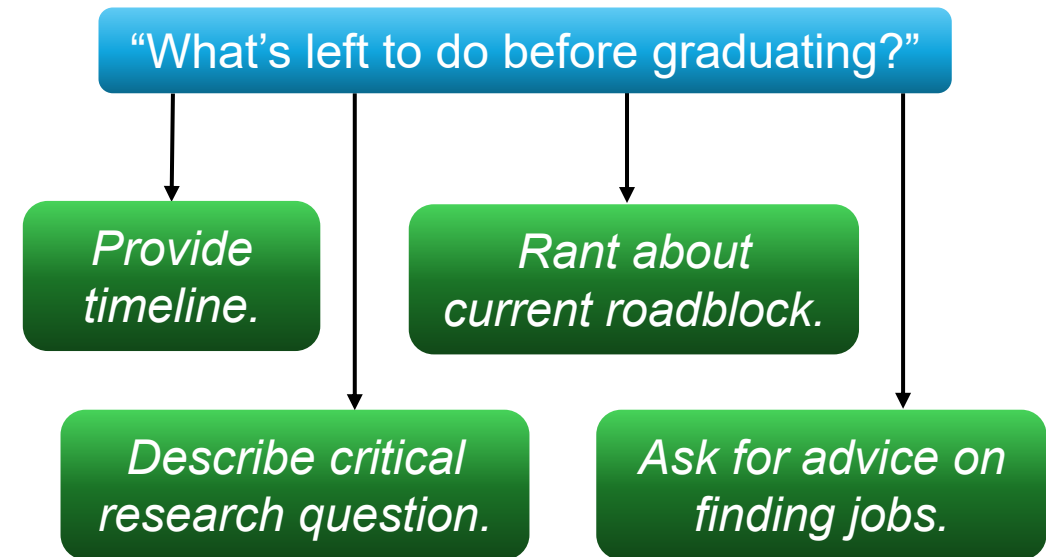
- **Strategic questioning** is “the skill of asking the **questions that will make a difference**” [1]

- Promotes **dynamic flow** in conversation
- **Multiple options** for how to answer (avoid binary “yes/no” or “true/false”)
- Make person **think deeply when responding**
- **Both parties feel empowered** by conversation

Static questioning:



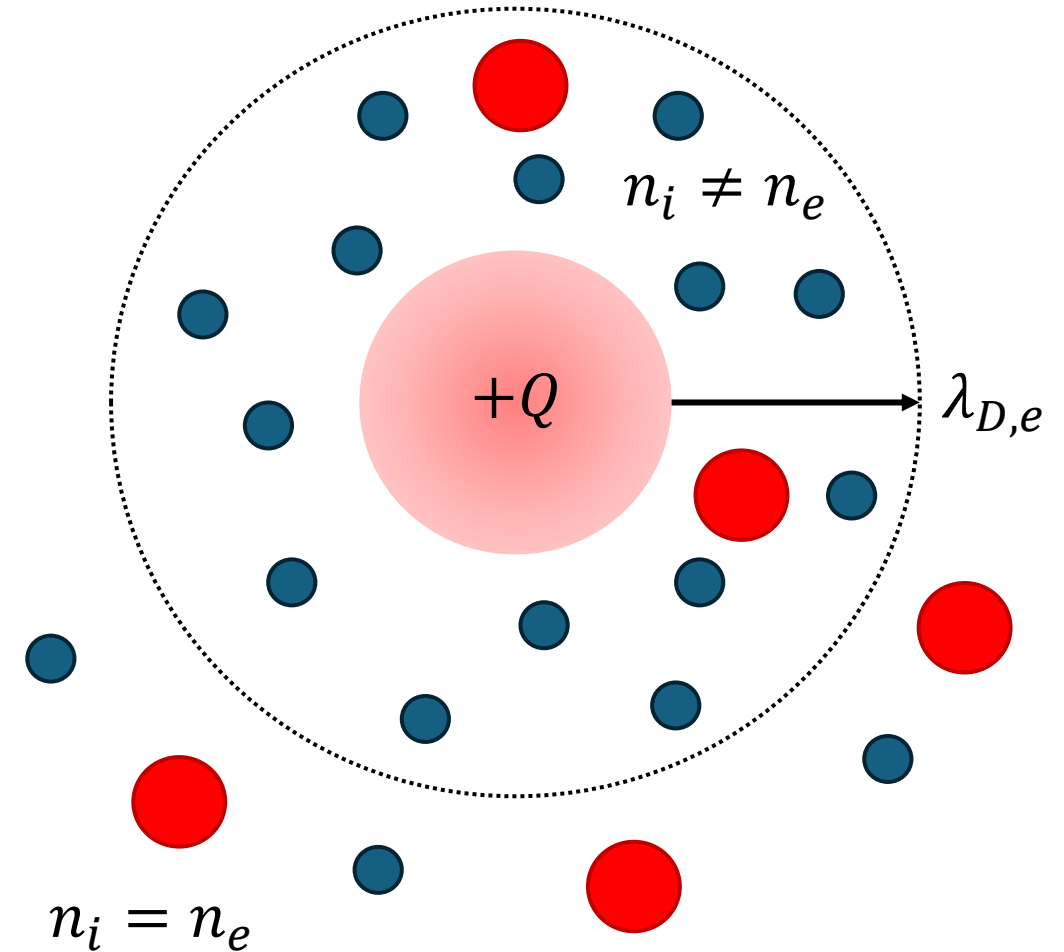
Strategic questioning:



[1] F. Peavey, P. Woodrow, T. Green. *Insight and Action*, New Society Publishers (1994).

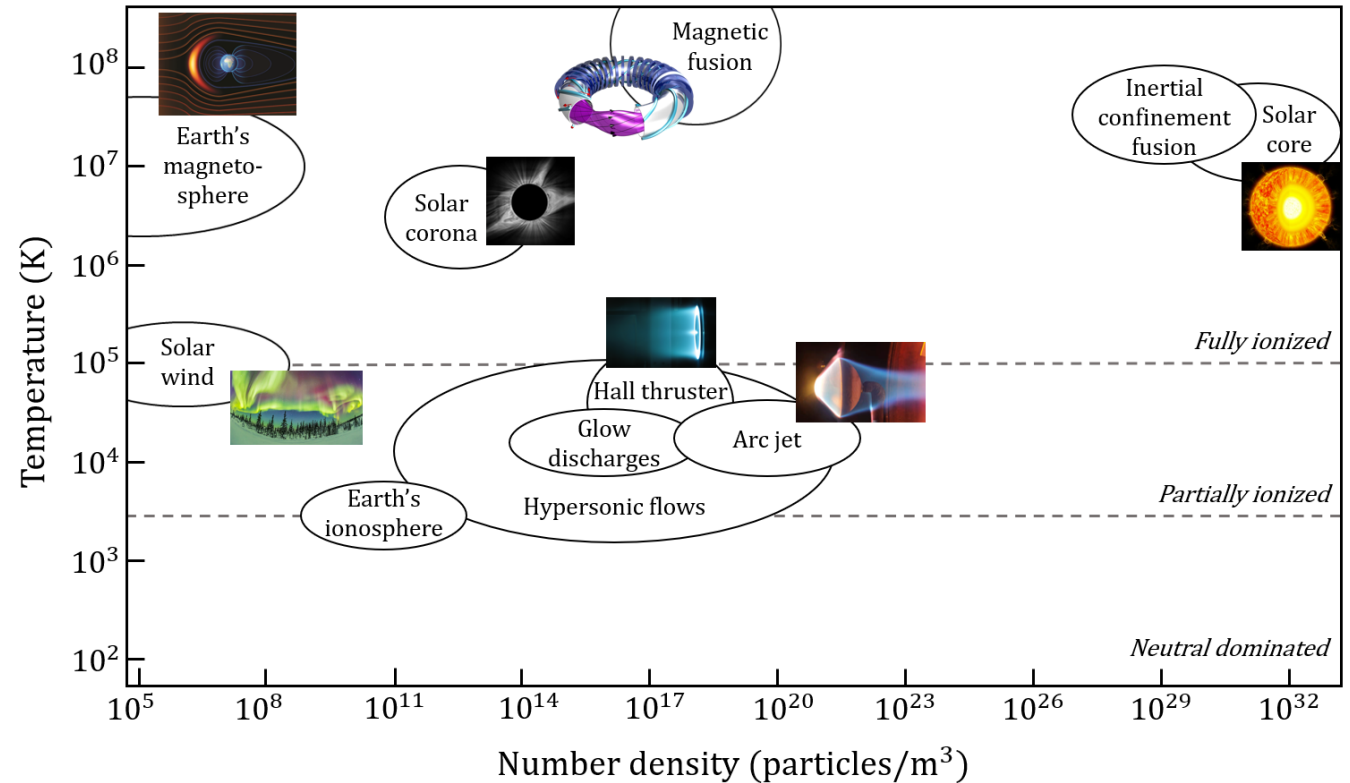
Practice: A Standard Question for Plasma Physicists

- “What is the definition of a plasma?”
- **Answer:**
 - $\lambda_D \ll L$
 - $N_D \gg 1$
 - $\omega_p \tau > 1$
- **Critiques** from “strategic questioning” point of view:
 - Only **one correct answer** (by design)
 - **Need prior knowledge** of plasma physics to respond
 - For some learners, **not illustrative** of what a plasma is



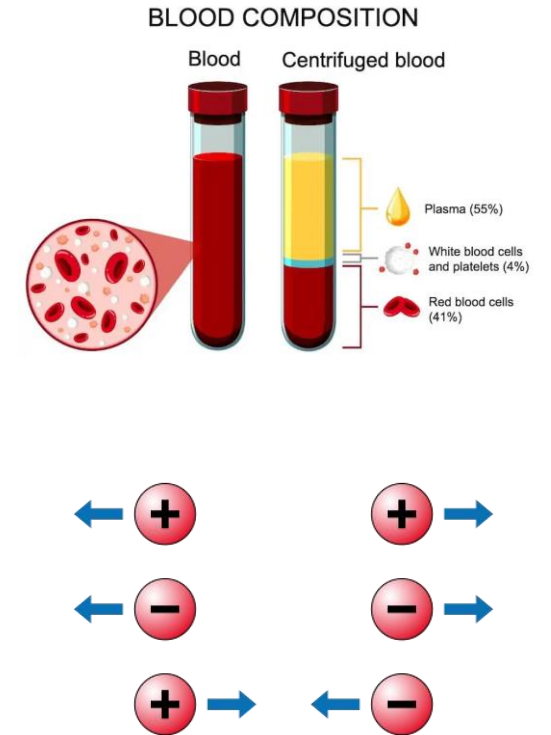
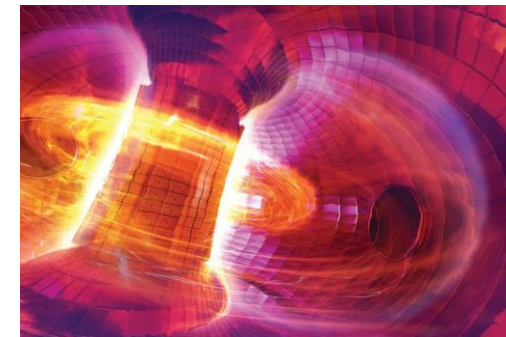
Let's Re-Design that Question, "Strategically"

- “What are some examples of a plasma?”
- **Improvements** from “strategic questioning” point of view:
 - **More variety** in possible correct answers
 - **Gain intuition** for students’ prior knowledge and interests
 - Can **segue into technical definition**
 - **Provides visuals** for students
- **Critiques** from “strategic questioning” point of view:
 - Still a firm boundary between **correct and incorrect responses**
 - **Still need prior knowledge** of plasma physics



There's Always Room for Improvement: Re-Design Again!

- “What comes to mind when you think of the word ‘plasma’?”
- Improvements from “strategic questioning” point of view:
 - Any answer is valid
 - No prior knowledge needed
 - Build off of responses throughout lecture
 - “Co-construction of knowledge”
- Critiques in general:
 - Students may still be afraid of “being wrong”
 - Unequal participation from students
 - Only as useful as the technical content that follows it (dialogic learning must enhance STEM coursework, **not replace it**)

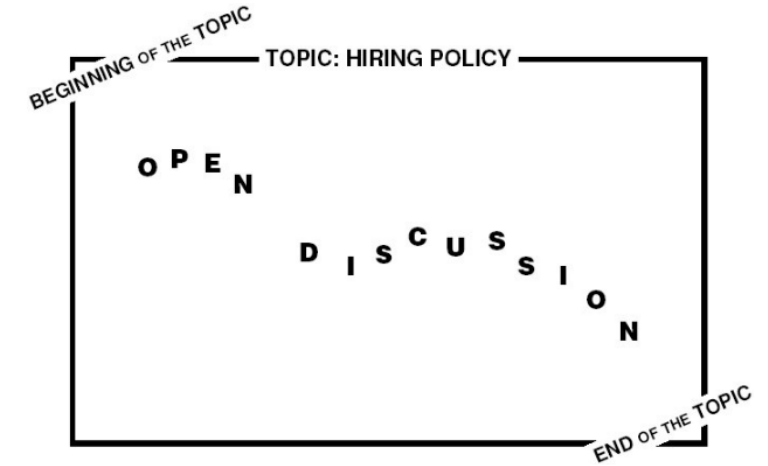


“Fourth state of matter”

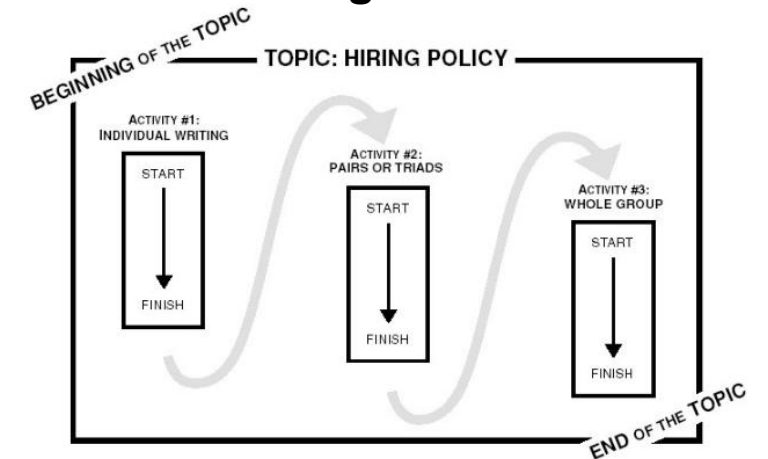
Step 2: Choosing and Planning a Participation Format

- Why does dialogue **need a participation format**?
 - Open discussion puts **pressure to answer quickly**, and students may **not have time to thoughtfully think**
 - Encourages **broader participation** from class
 - Easier to **plan timing** during lesson (allocate by minutes)
 - Reduces chance for silence (although silence is nothing to be afraid of!)
- **Things to Consider:**
 - **Learning styles, personalities, backgrounds** of students
 - **Time constraints**
 - **Hybrid learners**
 - **Prior lectures'** content

Unstructured discussion:



Structured dialogue:



[2] S. Kaner. *Facilitator's Guide to Participatory Decision-Making*, John Wiley and Sons (2007).

Some Formats Well-Suited for STEM

- ***Individual Writing***

- No fear of speaking up or being wrong
- Online students can **pause and participate**
- **No 'verification' of responses** (best paired with another participation format)

- ***Small Groups/Turn and Talk***

- Encourage **peer-to-peer** connection
- Perfect for **lab classes!**
- **Everyone prefers their friends** (encourage moving across the room!)

- ***Structured Go-Around Discussion***

- Encourages **participation from more students**
- **Some voices may still dominate the dialogue** (requires good facilitation skills)



[2] S. Kaner. *Facilitator's Guide to Participatory Decision-Making*, John Wiley and Sons (2007).

Step 3: Facilitating Constructive Dialogue

- Dialogue is **only as effective as its facilitator** (you, the educator!)
 - Dialogic learning is designed to **expose participants to different or conflicting ideas**, helping them **refine their own views and values**
 - Can lead to moments of conflict, awkwardness, silence
- “What **values/backgrounds should I be accounting for** as a physicist?”
 - Different **majors** (Physics v.s. Mechanical Engineering)
 - Different **career goals** (Academia v.s. Industry)
 - Different **motivations** for taking course (Course requirement v.s. Interested in topic)
 - Different levels of **prior knowledge** (Calculus 1-4, research experience, etc.)
 - Different **learning styles** (Not all physicists are mathematical learners!)
 - Different **confidence** levels (Both in terms of public speaking and material)
- **Facilitator moves** are best practices for facilitators to encourage healthy and productive dialogue

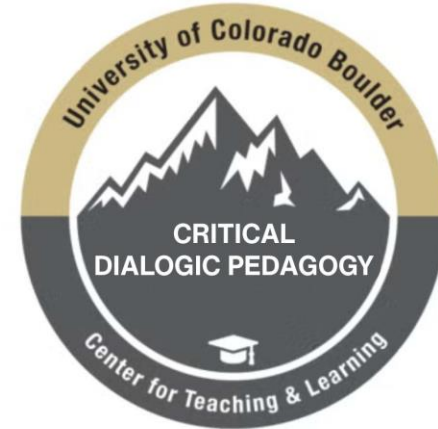
Some Facilitator Moves

Skill	Example	Why	How
Paraphrasing	"It sounds like you're saying... did I get that right?"	Re-assures speaker their ideas are worth listening to; Clarifies response	Use your own words to repeat what you think speaker said
Encouraging/Balancing	"Does anyone have a different idea?" "Let's hear from the right side of the room."	Some voices will dominate over others, bring more participants into conversation	Create an opening for people to participate without calling out individuals
Intentional Silence	"Let's all take a minute to think about this."	Many people need time to organize their thoughts	Call out that the silence is intentional and acceptable
Summarizing	"What I'm hearing from everyone is that we should..." "Some students want to... but others want to..."	Determine a main takeaway from dialogue to remember	Identify commonalities between responses

You may already do many of these “moves” on a regular basis!

Concluding Remarks

- It takes creativity, preparation, and practice, but **dialogic learning** has the potential to **enhance STEM education for both students and educators**
 - **Skills are universal:** can use techniques for office hours, research group, organizing committees, conference session chairing, etc.
- If you start incorporating dialogic learning, let's connect and share strategies!
- Special thanks to my co-authors and organizers of the **Critical Dialogic Pedagogy Micro-credential workshop series**, hosted by the [CU Dialogues Program](#) at the University of Colorado Boulder!



Thank you for listening!
Contact: marisa.petrusky@colorado.edu

Scan for a copy of the slides!

References

- [1] F. Peavey, P. Woodrow, T. Green. *Insight and Action*, New Society Publishers (1994).
- [2] S. Kaner. *Facilitator's Guide to Participatory Decision-Making*, John Wiley and Sons (2007).

Backup Slides

Practice Designing a Strategic Question!

- **Practice** writing dialogically informed questions with the following activity:
 1. Take ~5 minutes to write down a “standard” question you would pose to students in your class
 2. Next, reword or re-design the question at least twice using strategic questioning practices
 3. *Reflection:* What were your intentions with the original question? How (if at all) did the re-designs better meet those intentions?
- *If working in a group:* Have each person share their standard question and re-designs. Reflect together on how each re-design improves the previous, possible areas for improvement, and how well dialogic framing fits your content area.

Participation Format Examples

- **Popcorn Go-Around:** Anyone can call out a short response (< 1 sentence) to the prompt.
 - “Name one thing you remember from last class. It can be anything: the color of my shirt, a single variable letter, a lesson learned.”
 - Invite students to respond: “I want to hear from at least new 3 people!”, “Someone in the back!”
- **Hand-Raising:** Ask questions that can be answered by raising hands or holding up fingers
 - “Hold up your hand, on a scale of 1-5, how comfortable do we feel about the exam?”
 - “Who thinks the answer is A? Who thinks the answer is B?”
- **Intentional Silence:** Allow a minute or two of silence for students to process information.
 - “That was a long derivation, let’s take a moment to think about it. If you have any questions, feel free to write them down.”

Participation Format Examples

- Can also combine formats! ***Individual Writing*** → ***Pair Share*** → ***Open Discussion***
 - GOAL: Assign a homework where students will code a charged particle moving through a user-input electromagnetic field. Reserve last 10 minutes of class for students to start thinking about assignment.
 - 1. “Take 4 minutes to write pseudo-code for the homework prompt. Be sure to mention how users will input parameters, such as the electric and magnetic field values, into the code.”
 - 2. “Take 4 minutes to share your pseudo-code with the person next to you. Offer warm and cool feedback on their work so far.”
 - 3. *For last 2 minutes:* “Share one piece of warm feedback you gave your partner.”
 - NOT recommended to share out cool feedback

Participation Format Examples

- ***Individual Research → Small Groups → Present in Front of Class***
 - GOAL: Have students present on a variety of plasma physics subfields during the last week of classes.
 - 1. Have students arrange themselves into 4-person groups. Each group is assigned a chapter to read from the textbook for homework.
 - 2. Next class, have each group work together on developing a “mini-lecture” on their textbook chapter.
 - a. Consider using fun materials, like easel pads and markers!
 - 3. For the final class, have each group present their mini-lecture to the class.

Practice Scenarios and Possible Facilitator Moves

- ***You address a question to the entire class. One student answers, but the rest are silent.***
 - *Pivot* to a different participation format
 - “Let’s take a couple minutes to think about this question more deeply. Jot down any thoughts you have.”
 - *Encouraging/Balancing*: Build off of Student A’s answer and invite others to join in.
 - “Does anyone have a different idea?”
- ***A student is answering your question, but you’re not quite sure what they’re saying.***
 - *Paraphrase* to clarify your understanding of their response.
 - “If I understand you correctly, you’re saying that... Did I get that right?”
 - *Draw out* parts of their response that are unclear.
 - “Can you elaborate more on the second part of what you said?”

Practice Scenarios and Possible Facilitator Moves

- ***During office hours, Student A keeps asking follow-up questions. There are several other students waiting, and you want to get to their questions.***
 - *Deliberate re-focusing:* Re-direct the conversation in a respectful manner.
 - “We’ve been talking about Question 1 for a bit, I’m sure everyone is benefitting from our discussion. But, I want to make sure we address other parts of the homework. Would anyone else like to ask a question?”
 - *Using the Clock:* Mentioning time constraints can help reset the conversation
 - “I appreciate your questions. There are 15 minutes left in office hours, so I’d like to make sure we’ve heard from everyone. You are more than welcome to send those follow-ups via email.”
 - *Stacking:* Create an order for students to participate.
 - “I’d like to check in with the rest of the group. Please raise your hand if you’d like to speak. Okay, I’ll answer your last question, Student A, and then we’ll have Student B and Student C go.”

Practice Scenarios and Possible Facilitator Moves

- ***A senior design team is arguing. Several voices seem louder than others. They call you over to resolve the conflict.***
 - *Validate*: It's important for all parties to know you value their ideas, even if you are inclined towards some more than others.
 - "I hear what you're saying and appreciate your attention to detail. I also appreciate Student A's concerns about timeline and feasibility."
 - *Making Space*: Not all participants want to be singled out. But, you might notice cues that someone wants to speak and directly invite them to participate.
 - "Student B, did you have something you wanted to say?"
 - Non-Verbal Cues: Holding up index finger, raising chin, crinkle nose, pursed lips